U. S. DEPARTMENT OF AGRICULTURE

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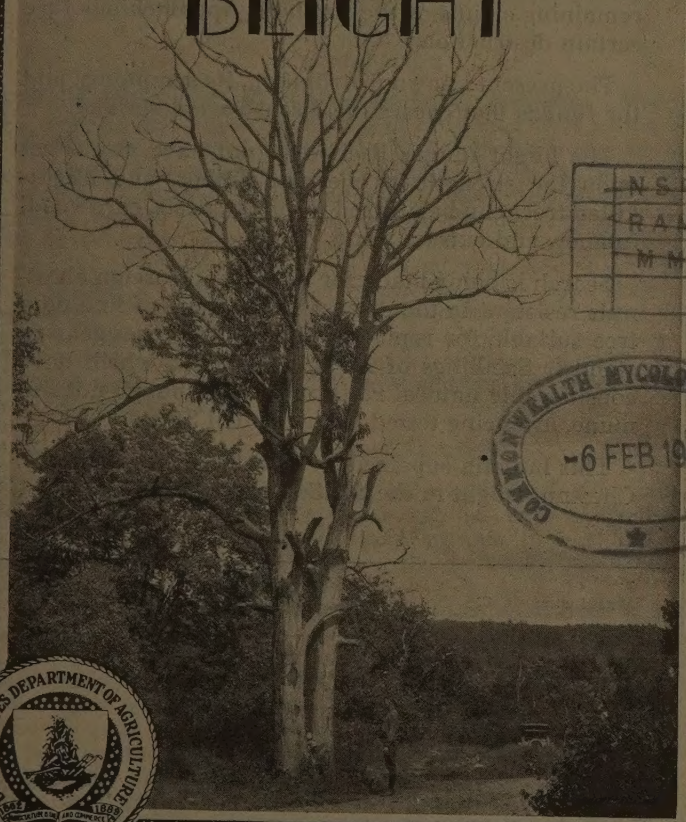
CHESTNUT BLIGHT



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CHESTNUT BLIGHT, caused by a fungus brought into this country from Asia before 1904, is responsible for the death of millions of acres of chestnut growth in New England and the Middle Atlantic States. The disease spread rapidly to nearly all parts of the range of the native chestnut, and the remaining stands of the southern Appalachians face certain destruction.

The present known distribution, its symptoms, and the fungus that causes the disease are described.

The blight fungus itself does not have any effect upon the strength of chestnut timber, and blight-killed trees can be utilized for poles, posts, cordwood, lumber, and extract wood.

Search is being made for native and foreign chestnuts resistant to the disease in the hope of finding a tree suitable for replacing the rapidly disappearing stands. Seedlings of Asiatic chestnuts, which have considerable natural resistance even though not immune, are being tested in the United States.

This bulletin supersedes Department Circular 370, Chestnut Blight in the Southern Appalachians.

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CHESTNUT BLIGHT

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INTRODUCTION

THE PARASITIC FUNGUS, *Endothia parasitica* (Murr.) A. and A., that causes the disease of chestnut known as the blight or bark disease, was brought into the United States from Asia before this country had enacted plant-quarantine laws. As is often the case with introduced plant and insect pests, the chestnut-blight organism proved to be more virulent in the home of its adoption than in its native habitat. Chestnut blight was first observed and recognized as a new disease in this country at New York City in 1904, though it must have been present for some time previous to that date. The millions of acres of chestnut growth north of the Potomac River and east of the Allegheny Mountains have been killed by the blight fungus, and the remaining American chestnut stands of the southern Appalachian Mountains are heavily infected and face certain destruction.

SPREAD OF THE BLIGHT

The disease spread rapidly from its original infection center at New York City and later from other centers. It soon covered New England, but it made its most rapid advance in a southwesterly direction from New York City along the eastern slopes of the Blue Ridge and Allegheny Mountains.

The blight fungus not only spreads from infected trees to healthy ones near by, but often it is carried for long distances on shipments of chestnut poles or nursery trees and by birds or wind. Under favorable conditions such distribution of the fungus may result in new centers of spread, known as spot or advance infections. The rapid progress of the blight over the chestnut area is largely due to the fact that these advance infections become established many miles ahead of the main infection area. These advance spots rapidly enlarge, run together, and form a continuous infected area. The plan of the early work in Pennsylvania and other States was to locate

and cut out these advance infections to delay the spread of the disease. The cutting-out work in Pennsylvania resulted in marked delay in the spread of the disease across that State.

The blight has now extended to nearly all parts of the range of the native chestnut. In the extreme southern and western parts of its botanical range there are probably a number of small healthy stands of chestnut, but the steady spread of the blight means that these will be infected soon. The disease reaches isolated small stands of native chestnut that are many miles from any other chestnut or chinquapin growth. As the southern chinquapins are susceptible to the blight, these bushes will serve as hosts for the disease in localities where no native chestnuts grow. The percentage of infection in the southern Appalachians can be expected to increase steadily until the stand is finally killed. Table 1, based on observations on certain areas in Maryland and Virginia, gives a fair idea of the general rate at which infection and killing can be expected to increase, after the stand reaches the stage of 1 per cent infection.

TABLE 1.—*Rate of increase in chestnut-blight infection after 1 per cent infection has been reached*

[Percentages based on studies made on a number of areas in Maryland and Virginia]

Period after infection reaches 1 per cent	Healthy	Infected			Period after infection reaches 1 per cent	Healthy	Infected		
		Infected but not dead	Dead	Total			Infected but not dead	Dead	Total
Years	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Years*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	97	3	0	3	8	5	80	15	95
2	90	10	0	10	9	1	69	30	99
3	80	20	0	20	10	0	45	55	100
4	60	40	0	40	11	0	25	75	100
5	40	60	0	60	12	0	15	85	100
6	20	78	2	80	13	0	10	90	100
7	10	85	5	90	14	0	5	95	100

PRESENT DISTRIBUTION

The estimated distribution of the chestnut blight in the southern Appalachians in December, 1929, is shown in Figure 1, which is based primarily on reports of cooperators and supplemented by very limited survey work by members of the Office of Forestry Pathology. The degrees of infection and killing are estimated upon a county basis, though the actual infection within a county varies greatly. For example, a county having an average of 50 per cent of its trees blighted usually contains areas where the actual infection is less than 5 per cent and others where it is over 95 per cent. In using the map it must be remembered that these figures on infected and killed trees are not the result of detailed surveys of each county but are merely estimates based upon the best available information in the fall of 1929.

No detailed records are available upon the prevalence of blight in the scattered tracts of chestnut timber in those parts of the Southern States outside the Appalachian Mountains where the species is of minor importance. In a general way it is known that a major part

of this scattered growth has been killed in eastern Virginia; that a large percentage of it is infected in North Carolina, Kentucky, and Tennessee; and that a few scattered infections are present in Alabama and Georgia. Extensive inspection work would undoubtedly result in the finding of widespread infection in this scattered growth.

The blight has been reported on wild and planted chestnuts at a number of points in Indiana and Michigan. A large percentage of the chestnut growth in Ohio is infected or killed, the severity of infection being less in the southwestern than in the eastern part of the State.

Nearly all of the original chestnut trees have been killed in the Middle Atlantic and New England States. In the northern parts of New York and the New England States the blight has also killed many of the isolated trees at the extreme edge of the distribution area of the species. It has also been reported at a number of places in Ontario, Canada.

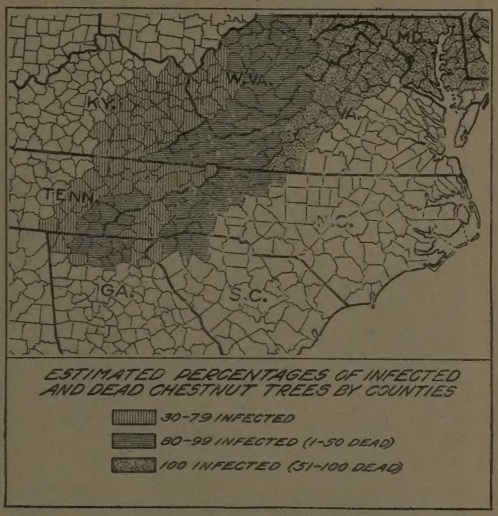

FIGURE 1.—Estimated distribution of blight in the more important chestnut counties of the southern Appalachians in December, 1929. Each year the degrees of infection and killing increase

SYMPTOMS OF THE DISEASE

The symptoms of blight are so characteristic that owners of chestnut should have no difficulty in recognizing the disease. The yellow or brown leaves of a dead branch, standing out in striking contrast to the green foliage, are usually the first-noticed indications of the presence of the chestnut blight. If the branch is killed in early spring, the dead leaves are smaller than normal ones (fig. 2), while if it is killed later in the season the leaves usually attain their full size. The dead leaves and burs of killed branches, which usually remain attached during the winter, afford a means of detecting blight infections at that time of year. Dead limbs without leaves or burs often indicate the presence of the blight. Occasionally dead branches with attached leaves result from causes other than the blight, but when the blight fungus, which is described in detail on page 7, is responsible, a close examination of the stem or branch will reveal the presence of a canker located on the branch or the trunk, usually somewhat below the lowest killed leaves. The sprouts or suckers that frequently develop below cankers aid in locating them. (Fig. 3.)

Cankers on smooth bark are easily recognized by their yellowish brown surface color, which contrasts sharply with the grayish green color of normal bark. The margin of the canker may be slightly raised in some cases, and in others it may have a water-soaked appearance, especially on vigorously growing shoots. Usually the margin of the canker is fairly regular (fig. 4), but

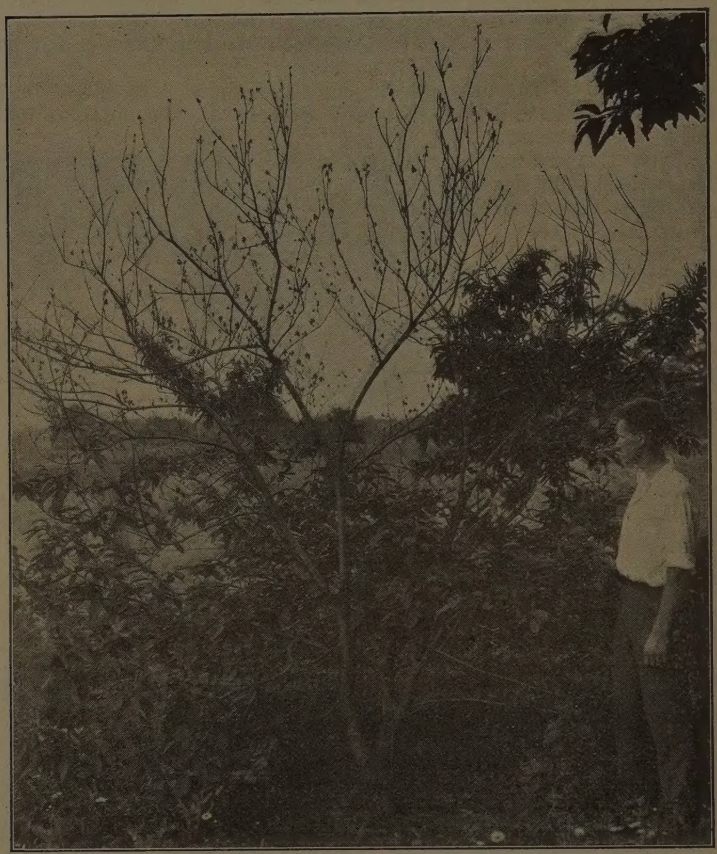

FIGURE 2.—An orchard chestnut partly killed in early spring. It shows very small leaves in contrast with normal ones

sometimes it is irregular. (Fig. 5.) There is less contrast between the appearance of the canker area and its margin on slowly growing shoots or twigs.

The cankered areas may be either sunken below or raised above the surrounding healthy bark, or a single canker may have both sunken and raised parts. When the fungus promptly kills the bark all the way through to the cambium and into the wood, there results

on smooth shoots a sunken area, which usually has a smooth, uncracked surface; but when it fails to kill the cambium, new layers of bark cells are formed underneath the attacked area and an enlarged lesion results. The swollen cankers usually have a number of longitudinal fissures or splits. (Fig. 6.) Frequently cankers have a smooth sunken area of bark in the center (fig. 6) and raised margins with cracks and fissures in the swollen parts.

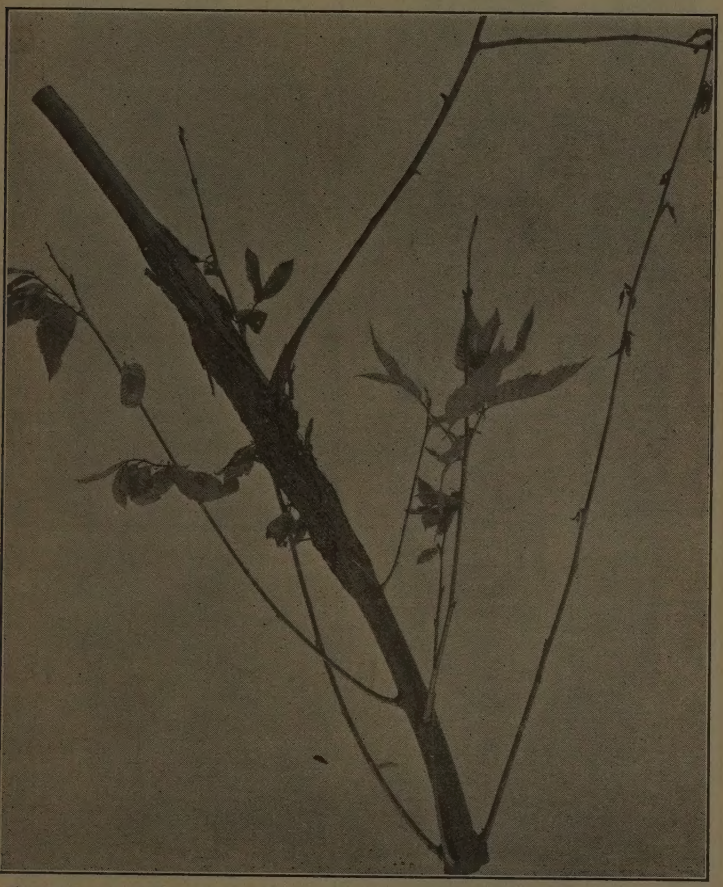

FIGURE 3.—A swollen blight canker with suckers developed below the infected area

On large thick-barked limbs and trunks a young blight infection causes very little change in the outward appearance of the bark. As the disease progresses abnormal splits or cracks often appear and expose some of the buff-colored infected inner bark, which is different in color from the surface bark. The presence of yellow, orange, or reddish-brown pustules about the size of a pinhead in

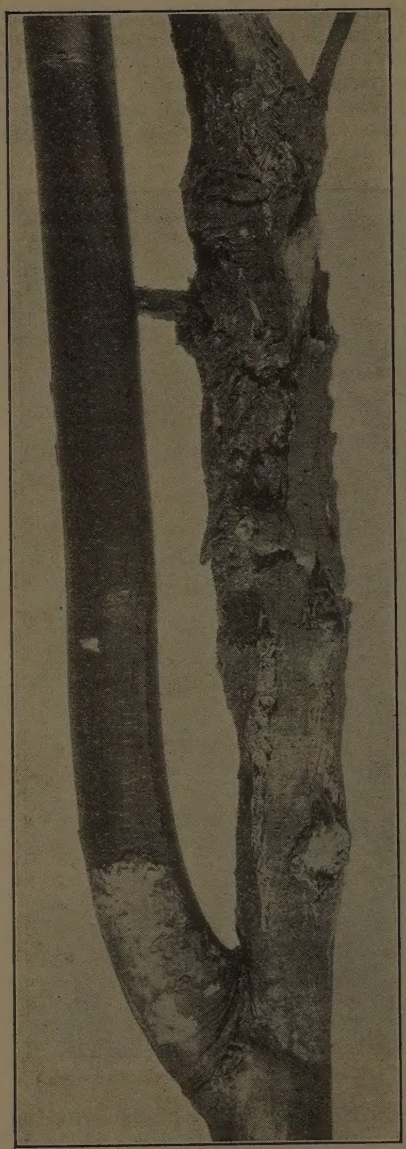

FIGURE 4.—Old blight canker spreading to a sprout. The canker developed there had a regular margin

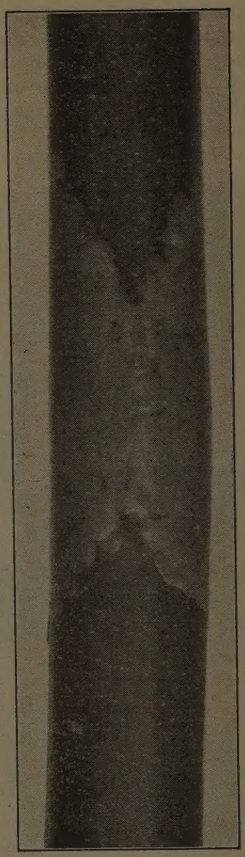

FIGURE 5.—A blight canker with an irregular margin. The fungus started on the opposite face of the limb and the two edges of the lesion have just grown together

the cracks or crevices of the thick bark is another indication of the disease. These pustules develop much more abundantly on the surface of cankers on smooth young growth than on those on thick-barked stems.

In many localities in the Southern States, especially at the lower elevations, many of the chestnut trees have died presumably from a root-rot disease that is quite distinct from the chestnut blight. Trees

affected by the blight always have cankers that show the typical fruiting bodies and cycelial fans as described on page 7. (Fig. 7.)

THE CAUSAL ORGANISM[1]

The vegetative part of the blight fungus, which is made up of very numerous flattened threadlike strands, is called the mycelium.

FIGURE 6.—The central part of the canker at the left is sunken where the fungus has killed the bark through to the wood. The canker at the right is slightly swollen with characteristic cracks.

It grows in the bark, extending much like the roots of plants in soil. As the fungus penetrates, it brings about the death of the invaded bark. The mycelium within this dead area is buff colored, but where it extends into the living bark at the margin of the lesion it is often

[1] SHEAR, C. L., STEVENS, NEIL E., and TILLER, RUBY J. ENDOTHIA PARASITICA AND RELATED SPECIES. U. S. Dept. Agr. Bul. 380, 82 p., illus. 1917.

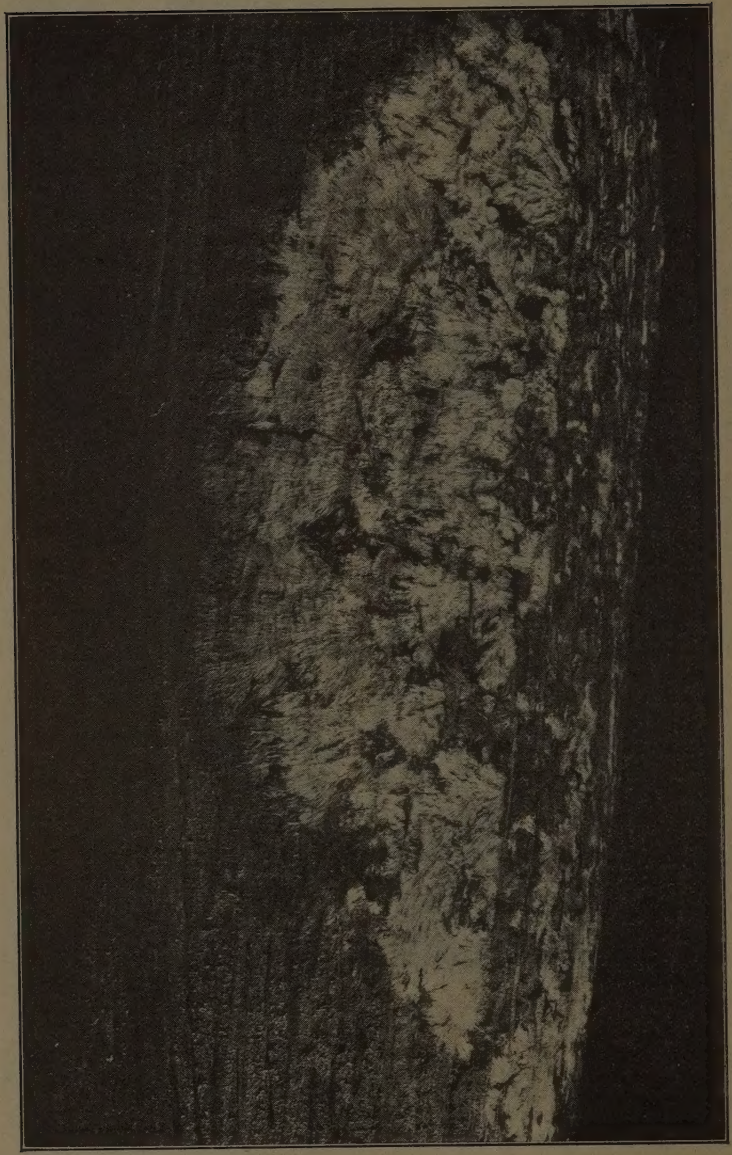

FIGURE 7.—Mycelial fans of the chestnut-blight fungus. This is one of the most important diagnostic characters. Usually the mycelial fans are much less abundant than in this specimen

white. The term "fans" has been applied to describe these thin spreading plates of fungous growth. (Fig. 7.)

When well established the fungus fruits. The reproductive bodies formed, corresponding to the seeds of plants, are known as spores. Two types of spores are produced from pustules, which in dry weather resemble orange or red-brown pinheads dotted over the surface of the cankers. (Fig. 8.) During damp weather certain pustules produce tiny yellow, coiling, hairlike tendrils, called spore horns (fig. 9), which are composed of myriads of spores about the size of bacteria. These spores are borne within the pustule in such

FIGURE 8.—Fruiting bodies of the chestnut-blight fungus

numbers that when moist they are forced out in a slender serpentine mass, much as paste is squeezed from a tube. Spores of this type are sticky when moist. They adhere to insects, birds, and animals coming in contact with them and thus may be carried long distances. Rain dissolves the dry spore horns and washes the spores into worm-holes and wounds to start new cankers.

Pustules producing the second type of spore differ from those producing the first in that during wet weather they are dotted with very small openings rather than surmounted by spore horns. The openings, which are often at the end of small protuberances (fig. 8), are the mouths of flask-shaped structures. Within the flasks the spores are borne, definitely arranged in groups of eight 2-celled spores. Each group is inclosed in a thin, transparent, club-shaped

sac. Under suitable conditions the sacs escape through the neck of the flask. When free the sacs burst in miniature explosions, throwing the spores into the air. Thus freed the spores are carried by air currents often to great distances.

FIGURE 9.—Spore horns of the chestnut-blight fungus. About six times natural size

The enormous numbers in which both types of blight spores are produced, together with the fact that they are adapted for different methods of dissemination, give insight into one aspect of the difficulty of halting such a foreign invader once it becomes widely established and begins its march.

DETERIORATION OF WOOD

Tests made by the United States Forest Products Laboratory [2] indicate that for a year, or possibly two years, wood from blight-killed chestnut is as good as that from healthy chestnut. As the blight fungus itself does not appear to have any immediate or after effects upon the mechanical strength of the timber, the utilization value of a blight-killed chestnut should be no less than that of a tree ringed with an ax at the same time and left standing. Soon after the death from either cause, the loosening of the bark, which is accompanied by decay of the sapwood, becomes apparent. Figure 10 shows the average rate at which the bark was observed to loosen and

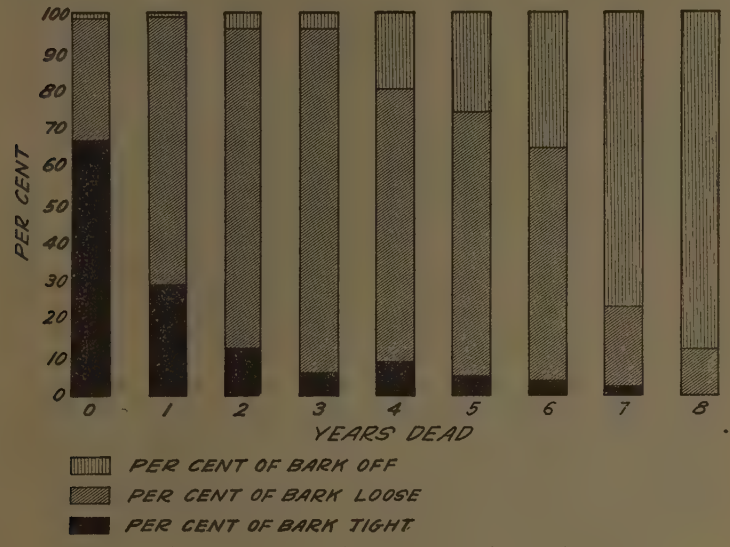

FIGURE 10.—Condition of bark on trees dead for periods of different length

fall from the first log of blight-killed trees at several localities in the southern Appalachians. The very rapid loosening during the first three years after death is brought about largely by insects and fungi, which finally cause it to slough off. Occasionally certain species of fungi also decay the heartwood to a depth of an inch or more. The amount of sound sapwood remaining on the first log during the first seven years after death is approximately the same as the amount of tight bark shown in Figure 10.

Since most of the loosened bark and decayed sapwood will be knocked off in felling operations, they can be considered almost a complete loss by the third or fourth year after death. The reduction in volume resulting from the loss of sapwood and bark on the trunks alone, where trees were cut into 5-foot sticks to a 4-inch minimum diameter for extract wood, is shown in Figure 11, which is

[2] A UTILIZATION GUIDE FOR BLIGHT-KILLED CHESTNUT. U. S. Dept. Agr., Forest Products Lab., Technical Note 224. [Multigraphed.]

based on 78 trees. It is evident that the loss in proportion to original volume is heaviest in trees under 8 inches in diameter. No data are available for trees above 17 inches, but allowing for a conservative increase in bark thickness with diameter, it is estimated that the loss will still closely approximate 20 per cent in the 30-inch diameter class.

The percentage of loss in limb wood will be consistently higher because of the greater proportion of small diameters. However, as the trunk volumes have been calculated to a 4-inch upper limit, the

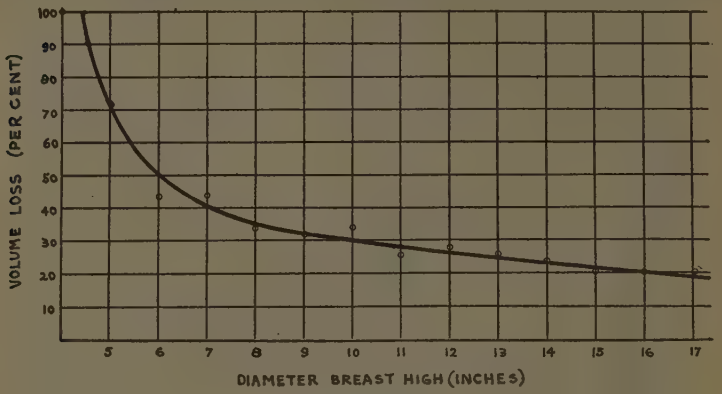

FIGURE 11.—Reduction in volume of extract wood in trunks resulting from loss of bark and sapwood

amount of wood remaining in the limbs is not great. Table 2 gives the amount of limb wood and the percentages of loss in 319 trees at one locality in North Carolina. The sapwood averages about one-fourth inch in thickness and comprises about one-third to one-fourth of the total amount lost.

TABLE 2.—*Limb-wood volumes and percentages of loss through bark falling and decay of sapwood*

Diameter breast high (inches)	Trees	Average volume of limb wood	Loss in bark and sapwood
	Number	*Cubic feet*	*Per cent*
15 to 19 inches	99	1.39	49
20 to 24	123	3.47	39
25 to 29	66	7.00	35
30 to 34	31	10.01	31

The heartwood of living chestnut is often attacked by certain fungi that cause it to decay. Some of these heart-rotting fungi are able to continue to decay the wood in standing dead trees, but how fast heart rot progresses in trees infected with rot before death is not known. In the case of sound trees there will probably be little danger of any material loss in volume from center rot for the first 10 years after death, and many standing trees have been found to be apparently sound 30 years after they have been killed. After 10 years, however, wind throw must be considered. Trees on the

ground usually deteriorate more rapidly than those that remain standing. Their centers are frequently destroyed within a few years by insects in combination with decay. The time required for blight-killed trees to fall is dependent upon a number of factors, among which are soil type, local weather conditions, relief, exposure, and prevalence of root decay. Observations on a number of belted or girdled areas in the southern Appalachians indicate that less than 5 per cent of the trees blow over during the first 10 years after death. From 20 to 40 per cent of those dead between 10 and 20 years and from 60 to 100 per cent of those dead for more than 20 years blow over. These estimates were made on girdled stands, as blight-killed areas of sufficient age were not available in the South. It is possible that under natural conditions windfall would be much less, since the dead chestnut would receive protection from the surrounding trees of other species.

Where a considerable part of the stand is chestnut, fire conditions become increasingly critical with the accumulation of bark, dead sprouts, and fallen branches at the bases of dead trees. Fires not only destroy part of the dead standing chestnut but also, on account of the intensity with which the accumulated dead material burns, frequently destroy other species in the stand. Adequate fire protection in the southern Appalachians would assist in the effort to utilize the chestnut growth and would materially prolong the life of the chestnut-extract industry.

Serious checking usually does not occur so long as the bark persists. Reference to Figure 10 shows that on the average approximately 65 per cent of the bark still remains by the sixth year after death. Checking is most rapid during the first two years after the bark has fallen. During this period several checks over 5 feet in length and 1 inch deep develop at fairly regular intervals around the trunk. The increase in size and number of damaging checks is very slow thereafter.

In addition, dead wood is liable to become brittle with long years of seasoning on the stump. It may also suffer from attacks of timber worms, resulting in lumber of lower grade. Occasionally stains are found in the wood of dead trees.

UTILIZATION OF BLIGHT-KILLED CHESTNUT

The problem of utilizing the chestnut timber from the 33,000,000 acres of the southern Appalachians, where the species represents 25 per cent of the stand, is one phase of the chestnut-blight problem which the United States Forest Service and State and extension forestry departments are endeavoring to solve.

Chestnut lends itself to the most varied usage of any timber species growing in the southern Appalachians. It is already used for extract wood, lumber, poles, ties, mine props, piles, fence posts, cordwood, and pulpwood, and it offers the possibility of increased use. Sawed chestnut lumber is much in demand, but increased cutting, because of the spread of the blight, tends to glut the market. The wood is light and easily worked. It can be used for many purposes where its coarse grain and lack of extreme strength do not make it undesirable. Its increased use for sheathing, framing, interior work, and most of all for the manufacture of boxes, packing cases, and crates, would do much to conserve other timber supplies.

Telephone and telegraph poles command the highest prices paid for chestnut. However, some purchasers demand that the poles be cut green and that they be not seriously damaged by blight, while others only specify that the sapwood be sound on the butt. For these reasons it is advisable for owners to market their poles as soon as practicable.

The manufacture of chestnut extract affords the most feasible outlet for much of the stand. Extract plants are already established strategically over the southern Appalachian district. (Fig. 12.) This industry, by far the largest consumer of chestnut, uses enormous quantities of the wood. It disposes of trees and parts of trees that are worthless except as acid wood. The limbs as well as trunks are

FIGURE 12.—A chestnut-extract plant. There are 21 chestnut-extract plants in the southern Appalachians, producing over one-half of the domestic supply of vegetable tannins

used, so that little waste remains in the woods to increase the fire hazard. Best of all, from the standpoint of the present situation, even the prolonged standing of dead timber does not exclude its use for this purpose.

Studies[3] have recently been carried out, in cooperation with the Bureau of Chemistry and Soils and with chemists of the chestnut-extract plants, on the tannin content of trees that had been killed by belting or by forest fires in a number of localities in the southern Appalachians. These trees are considered fairly comparable to blight-killed chestnuts. The studies indicate that the percentage of tannin in trees dead as long as 25 to 30 years is not materially less than that in living trees. Blight-killed trees lose their sapwood and bark within a few years after their death. However, the loss of the sapwood, which is thin and has a low tannin content (2 to 4 per cent), is of little importance. Even the loss of the bark, which has approxi-

[3] NELSON, R. M., and GRAVATT, G. F. THE TANNIN CONTENT OF DEAD CHESTNUT TREES. Jour. Amer. Leather Chem. Assoc. 24: 479–499. 1929.

mately the same tannin content as the heartwood (7 to 12 per cent), is not always a serious matter to the extract manufacturer, because peeled wood is necessary in some of the processes for utilization of the chips left after the extraction of tannin. Table 3 gives a brief guide for the utilization of chestnut.

TABLE 3.—*Condition and utilization of products from dead chestnut trees*

Number of years after tree died	Average condition of trees	Effect upon products (caused by death of tree)			
		Cordwood or extract wood	Poles (treated)	Poles and posts (untreated)	Lumber
1	Bark loosening and sapwood decaying on upper parts first infected.	Slight volume reductions from loss of bark in upper parts.	Nearly as good as green timber.	Nearly as good as green timber except for greater breakage in felling.	Nearly as good as green timber.
2 to 3	Bark loose and sapwood decaying on most of tree.	Loss of sapwood and bark practically completed. Volume loss 20 per cent on large trees and somewhat more on those under 10 inches.	Usually acceptable if sapwood remains sound on the butt.	do	Do.
4	Bark and sapwood all loose.	do	Not suitable	do	Do.
5	Bark off most of upper parts; checking beginning on exposed areas.	do	do	Value reduced, mainly on account of checking.	Loss in value and volume from checking; gradual increases in cull from decay.
6 to 10	Bark off; checking practically complete.	Practically no further volume loss.	do	do	Do.

BLIGHT-RESISTANT CHESTNUTS

Since direct control of chestnut blight is impracticable, the discovery of suitable strains of chestnut resistant to the disease is highly desirable. Individual native chestnuts differ in susceptibility to attack, but search for many years has shown that the number of trees actually surviving in regions where blight has been present the longest is very small. Some of these trees are being propagated and studied further with the hope of developing a strain of American chestnut sufficiently resistant to reach maturity in the presence of the disease. The numerous living trees occurring on tracts recently killed by blight are generally disease escaping rather than disease resistant. For this reason search for resistant specimens is profitable only in areas where all but very exceptionable chestnut trees have been dead from the disease for a number of years. Reports of unusually resistant trees—those that have not been severely injured by the blight—are desired. The Office of Forest Pathology records all such trees reported and inspects them as field work permits.

For a number of years after the chestnut trees in different localities were killed by the blight, the sprouts rarely reached a diameter of more than a few inches before they in turn were killed. Some sprouts now become much larger and frequently produce viable nuts before being killed by the blight. Other sprouts continue to grow and produce nuts in spite of the blight cankers on their stems. Just what will be the ultimate result of this struggle between host and

parasite can not be definitely stated, though it is reasonable to expect that by selection among the seedlings growing from the nuts of the sprouts a quick-fruiting, moderately resistant strain of the American chestnut will finally be evolved.

Many owners in different parts of the country have written to the Department of Agriculture at Washington for advice on how to keep their chestnut sprouts alive. Whether sprouts should be treated or not is a question that the individual owner must decide, but in nearly all cases treating sprouts is a waste of time and money. Treatments have to be repeated, and as the trees become larger the cutting out of new infections becomes increasingly difficult. In most cases it is to be expected that the disease will finally kill the sprout or tree. The same expenditures made in planting and caring for Asiatic chestnut

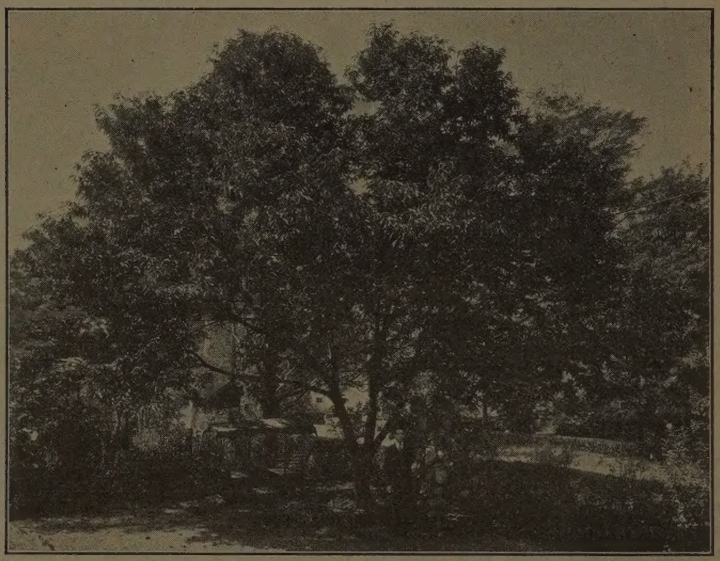

FIGURE 13.—An exotic chestnut tree, valuable for its beauty, shade, and edible nuts. The blight was cut out about five years ago, and it has not reappeared

trees will yield better returns in both nuts and shade. Figure 13 shows the effect secured with an exotic chestnut. To those who wish to work with the American chestnut for sentimental reasons, or because the sprouts are growing at hand on their land, suggestions for treatment will be sent upon request.

A number of strains of the Asiatic chestnuts have been brought to the United States by the Office of Foreign Plant Introduction [4] in the hope of obtaining a tree which will thrive despite the chestnut blight. None of the trees so far imported and tested have proved immune, but the Japanese chestnut (*Castanea japonica* Blume) and the hairy Chinese chestnut (*C. mollissima* Blume) (fig. 14) have considerable natural resistance to the disease. Private individuals

[4] GALLAWAY, B. T. THE SEARCH IN FOREIGN COUNTRIES FOR BLIGHT-RESISTANT CHESTNUTS AND RELATED TREE CROPS. U. S. Dept. Agr., Circ. 383, 16 p., illus. 1926.

have introduced Asiatic chestnuts, a large number of which are known to have survived the blight in various parts of the country, and reports of others are desired. Strains of these oriental chestnuts show marked differences in susceptibility, and it may not be practicable to control the blight on some of the very susceptible ones.

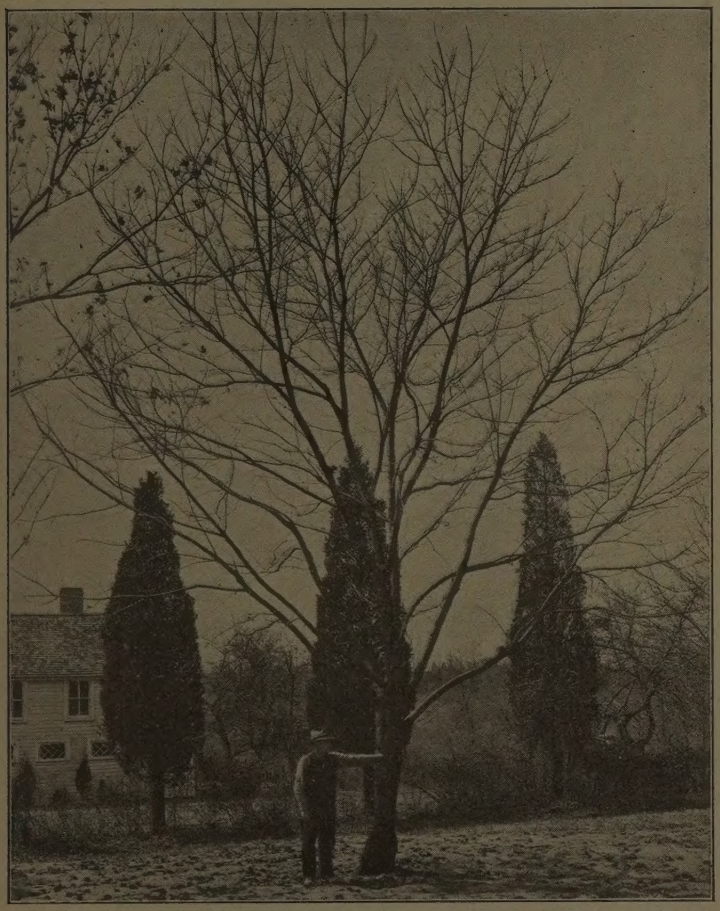

FIGURE 14.—A 17-year-old tree of the hairy Chinese chestnut growing at Bell, Md. This tree produced over a bushel of sweet nuts of good size in 1928, but only 2 quarts in 1929

However, most of the oriental trees can be saved by systematically cutting out any cankers that may appear and then painting the wounds. If the trees are kept in a vigorously growing condition, usually very little cutting out of cankers is necessary. Detailed information will be supplied by the Office of Forest Pathology, United States Department of Agriculture, to anyone interested in treating such trees.

Most of the imported chestnuts so far tested have been suited for orchard or ornamental purposes rather than for timber production. R. K. Beattie, of the Department of Agriculture, has been in Asia for the past two years securing nuts from the most promising trees of the forest types. Many thousands of seedlings from these forest trees are now growing in nurseries in the United States. These Asiatic chestnuts have shown marked resistance to the blight under

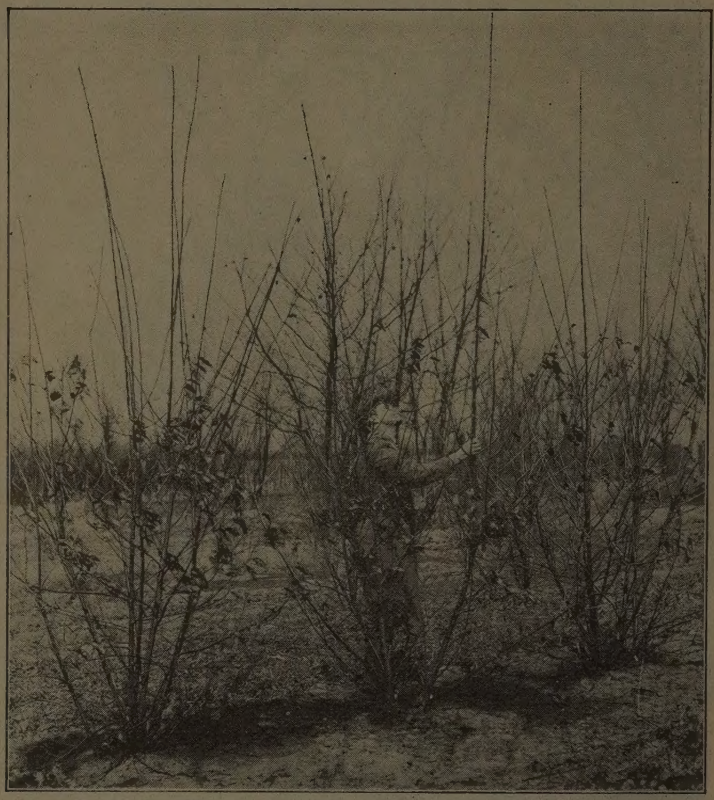

FIGURE 15.—Two-year-old coppice sprouts of hairy Chinese chestnut

the climatic conditions of their native home, and it is to be expected that they will prove resistant in this country. They do not grow so tall or straight as the American chestnut grows, but it is hoped that in addition to providing a home supply of nuts for the farmer some strains will prove suitable for small telephone poles, fence posts, and extract wood. Many strains of them coppice readily, as shown in Figure 15. Preliminary analyses of the wood of these Asiatic chestnuts indicate that it contains as much tannin as that of the American chestnut, if not more.

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